International Journal of Engineering Research (ISSN : 2319-6890)
Volume No.2, Issue No.3, pp : 204-208 01 July 2013

Study of Variations in Urban and Hydrological Components in Process of Urbanization

Sheetal Sharma, Alka Bharat, Vinay M. Das

Department of Architecture & Planning, Maulana Azad National Institute of Technology, Bhopal, India.
ar.sheetalsharma@yahoo.com, alka_bharat@yahoo.com, vinaymdas@yaoo.com

ABSTRACT:

In natural, undeveloped areas, a large percentage of relatively uncontaminated precipitation infiltrates the ground, thus recharging the ground water; the remaining runoff flows to nearby water bodies or evaporates.

Development alters natural systems as vegetation and open spaces are replaced with new areas of impervious surfaces such as roads, parking lots, roofs, and turf, which greatly reduce infiltration and thus ground water recharge. Uncontrolled stormwater runoff develops into Floods , even in normal intensity of rainfall causing loss of water recharge levels. The main carriers of water that is the natural Drainages ar either blocked completely of partially or forced to change their direction, in the process of Urbanization.

Thus water availability, water recharge and water Cycle all are destabilized in course or urban Development.

The paper is an attempt to closely identify the periodical changes in water cycle, drainages and recharge of Ground water and Water resources during urbanization of Bhopal City, India for Last twenty years and above. The observations made rely on GIS Mapping, Rational Method of Runoff Calculations, Recharge methods and statistical analysis of related built-up areas, the recharge, runoff changes. Also Change in Natural course of Drainages with help of GIS imageries during twenty years have been detected that help to observe the adaptation of natural system to urban course. Also a Comparative study of above changes and geological Characteristics of area have presented an interesting correlation of Water Recharge, urbanization and Geological responses. Thus a model is developed to study and analyze the effects of urbanization and to have guidelines for planning considerations of urban areas.

Key words: Geology, Drainage, Soil, Runoff, Pervious & Impervious areas, recharge:

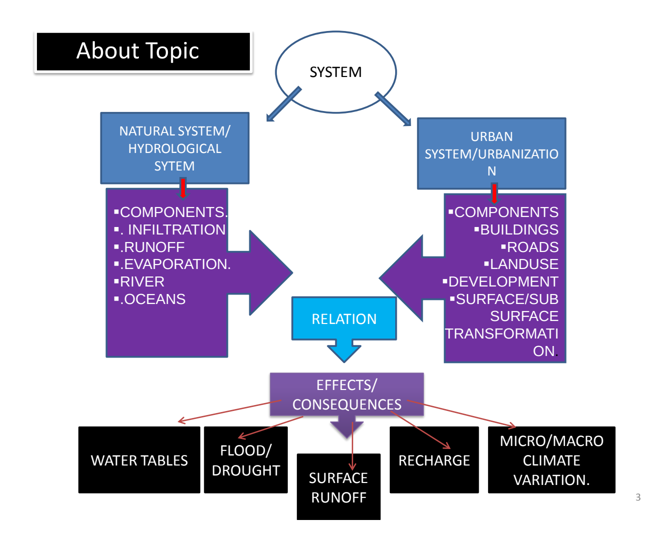


Figure 1. components of Urban & Hydrological Systems.

Urbanization and urban growth continue to be major demographic trends. The world's urban population increased from about 200 million (_15% of world population) in 1900 to 2.9 billion (_50% of world population) in 2000, and the number of cities with populations in excess of 1 million increased from 17 in 1900 to 388 in 2000.

MAIN COMPONENTS OF URBAN SYSTEMS:

- Built up Areas: Any Development, construction, alteration carriied out on natural surface to change in into impervious layer.
- Less vegetation: Removal of vegetation for roads, parkings, housing, facilities Etc.
- Impervious Layers: surface changed so that they loose the natural ability to soak, percolate rain water.
- Man Made Alterations: Alteration to physiography, geology, hydrological cycle and Natural resources by replacing them with modified ones.
- Physical Transformation of Landscapes: change from natural to artificial with different purposes and uses

- Function (Land Use): activities carried out on altered surfaces.
- Population: People breeding on piece of land , using its natural resources. Natural Resources: Land , Water, vegetation, Minerals, rocks, forest etc
- **Natural System of Water**: The water cycle or the hydrological is simply the constant movement of water from the sky to the ground and back again.
- The main components of the water cycle are precipitation, infiltration, evapotranspiration, surface and channel storage, surface runoff and groundwater storage.
- As part of that cycle, when rainwater falls to the ground, water moves through the channels to form, Ground water table, Recharge, Lakes, rivers etc.
- primarily in the ocean (97.3%),
- or in polar or glacial ice (2.1%)
- **Source:** integrated urban system modeling: methodology and case study using multi-agent systems 1Daniell, K.A., 2H.C. Somerville, 3B.A. Foley, 3H.R. Maier, 3D.J. Malovka and 4A.B. Kingsborough 1Cemagref/ENGREF, UMR G-EAU, Montpellier, France / Centre for Resource and Environmental Studies (CRES), Australian National University, 2Sinclair Knight Merz (SKM), Melbourne
- Urban Built up increases Impervious layers and hence Run off increases:
- The proportion of run off increases in urban areas (parking lots have low rates of infiltration)
- precipitation = runoff + evapotranspiration
- 30 inches/year = 9 inches + 21 inches (the ocean has to make up that 9 inches or the rivers would run dry)

2. RELATION: Urbanization and Water (Hydrology)

Several water related problems identified by American Journal of Applied Sciences , Lut Block, Iran**,** Ebrahim Moghimi , Iran,, *1st National Hydropolis Conference 2006, Burswood Convention Centre, Perth, Western AustraliaEmma Monk*1 *and Lisa Chalmers*2, Environmental Research Laboratory Office of Research and Development U.S. Environmental Protection Agency, ATHENS, GA 30613 such as:

- ❑ modification of microclimate,
- ❑ changed environmental conditions for water cycle,
- ❑ reduced capacity for water retention and
  - ❑ thus increased peak discharges that lead to vulnerability of extreme events (e.g., long-lasting droughts and extreme floods)
  - ❑ and deteriorated quality of water resources are become burning issues and challenges in the new global urbanized world.

REASON: Natural drainages have been replaced by human structures, or reengineered for human purposes. Human land use activities have imposed significant influences on watershed processes.

When an area is developed for housing or other urban purposes, the immediate hydrologic effect is to increase the area of low or **zero infiltration** capacity and to increase the efficiency or speed of water transmission in channels or conduits (Dunne and Leopold 1978).

3. BUILT UP AREA WORLWIDE: Table no.1 changes in Urban Percentage (World wide)

Year	Urban Percentage
1950	29.1
1955	30.9
1960	32.9
1965	34.7
1970	36.0
1975	37.3
1980	39.1
1985	40.9
1990	43.0
1995	44.7
2000	46.6
2005	48.6
2010	40.6
2015	52.7
2020	54.9
2025	57.2
2030	59.7
2035	62.2
2040	64.7
2045	67.2
2050	69.6

Source: http://esa.un.org/unup/p2k0data.asp

FIG-2-3 Rates of Growth in Population and Built-up from 1971 – 1999

Change in built-up area measured in this study compared to increase in population size as tabulated by the United Nations (Table 3.1). To facilitate comparison, data for all cities are presented at a uniform scale for population and area.

Source: http://eol.jsc.nasa.gov/newsletter/DynamicEarth/Chapter3/Fig8.htm

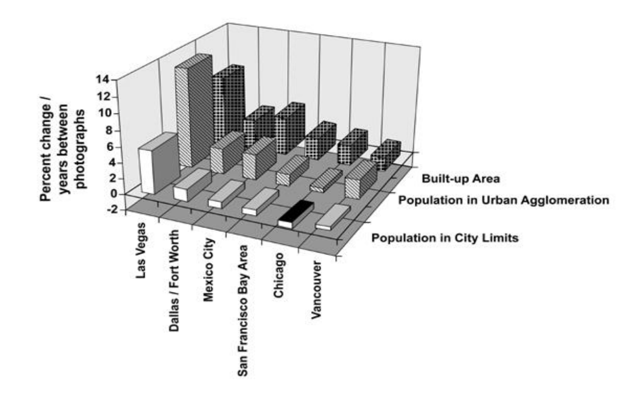


Figure -4 increase in Built up area in major cities of world

Percentage change in built-up area and in human population (population data compiled from UN figures described in Table 3.1). The total percentage change has been annualized by dividing by the number of years between photographs.

Source: http://eol.jsc.nasa.gov/newsletter/DynamicEarth/Chapter3/Fig9.htm

4. RUNOFF AND EVAPORATION WORLD WIDE:

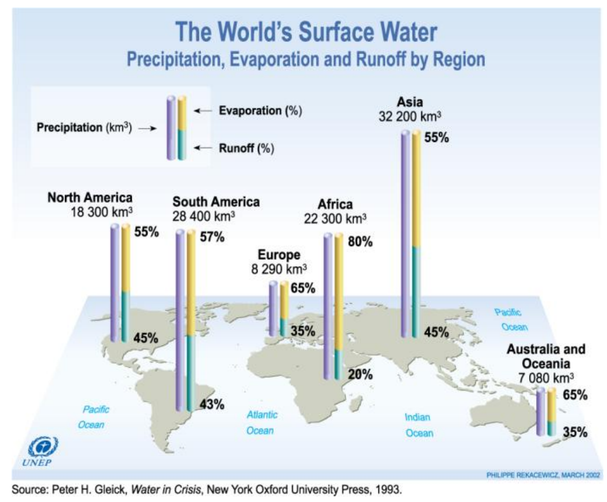


Figure -5 changes in runoff, evaporation.

5. RECHARGE WORLDWIDE:

	1961-1990 (A) [km³/a]	2050s (ECHAM4, A2) (B) [km³/a]	Change between A and B [%]
Groundwater recharge	12882	13112	+1.8
Total runoff from land	38617	42062	+8.9
Total cell runoff [1]	36621	39755	+8.6
Continental precipitation	107047	111572	+4.2

Table 2- shows the simulated changes of the global values of groundwater recharge, total runoff from land and total cell runoff (which includes evaporation from lakes and wetlands as well as evaporation of the water that is withdrawn for human water use). While both runoff values increase by approximately 9% between 1961-1990 and the 2050s .

Observation : The above figures and percentages show the changes in main components of both urban and Hydrological components.Similarly the changes were observed in Bhopal City of India during past 20 years.

1. Built up Area Calculation- Chronological Method using GIS Imageries for Subsequent years and calculating the urban sprawl by grid cover.



International Journal of Engineering Research (ISSN : 2319-6890)
Volume No.2, Issue No.3, pp : 204-208 01 July 2013

Changes in land use affect basins in the two hydrologic regimes differently. Where overland flow predominates, Run-off moves at rapid, surface flow rates. Thus, urbanization in regions of HOF (in which water runs over the land surface) increases the net percentage of precipitation that reaches the channel from surface flow and also affects the ground water recharge capacity in such areas.

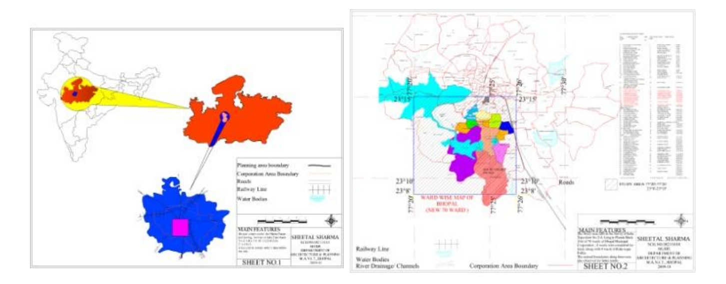


Figure-6 Bhopal City and Its Wards.

Human activities leading to development can have irreversible effects on drainage basin hydrology, particularly where sub-surface flow once predominated. Vegetation is cleared and the soil is stripped and compacted. Roads are layed , collecting surface and shallow subsurface water is continuous channels. Regrading eliminates previously undrained depressions. Sub-Surface utilities intercept yet deeper subsurface water and rapidly pipe it out of the basin as surface flow. Building construction is the most visible impact, but merely the final link in a long chain of hydrological changes. Construction adds impervious areas that intercept rainfall before it can reach the soil surface.

The study of Paper involves the impact assessment of changes in natural drainages in some wards in Bhopal City, India along with Villages in natural vicinity to predict the impact of urbanization and built up areas to natural recharging and subsurface flow of precipitation.

The villages having natural environment are also assessed to study impact of land use on different soils that lead to less Ground water recharge though having less urban development.

The results are compared to suggest the soil type, the percentage of built up allowable on natural surface so that natural processes are not affected and urbanization cope up with environment.

EFFECTS DUE TO URBANIZATION:

In highly urbanized area, a major flow peaks are amplified , and many new peaks also appear. These result from similar storms, some of which produce no storm runoff at all before development, but which now can generate substantial flows.

Thus , urban development does more than simply *magnify* peak discharges; it has also created entirely *new peak run-offs events.* As a result , floods of any given discharge occur much more frequently after urbanization. For example, if the discharge of the 2-year flood doubles following urbanization, then clearly the (smaller) discharge has now exceeded more frequently than every two years, on average. These changes in frequency are quite dramatic; discharges once associated with large , multi-year or multi –decade strom events now inundate the urban basin one or more times per year.

Urban development has not only increased flows , it has also encroached on the stream corridor – the zone surrounding the channel that has influenced the hydrology and biology of the flow . Frequently , this has lead to the clearing of streamside vegetation, particularly trees. The consequences of this clearing are two fold: First , less wood enters the channel , depriving the stream of stabilizing elements that help dissipate flow energy and usually help protect the bed and banks from erosion. Second , the overhead canopy of a stream is lost, eliminating the shade that controls temperature and supplies leaf litter that enters the aquatic food chain.

CONCLUSIONS:

The calculations show that the urban areas experienced changes in natural working of Drainage in different periods and having different Built up areas on it.

Calculations also show that as the impervious area increased there was dramatic change in runoff from that area which contributed to Flood and not to recharging of water.

Calculations also show that areas of agriculture use also have very little recharge even if they have very little Built up as these areas have different soil type but heavy pumping due unavailability of water supply.

The character of the urban land surface exert a profound effect on run-off processes, which in drainage basins are almost immediately expressed by the rate of storm runoff. Typically , only a fraction of the total precipitation falling on a basin actually reaches the stream channel. The remainder either:

1) never reaches the ground and is evaporated off the surfaces of vegetation;

2) enters the ground but is transpired by plants or evaporated from the soil; or

3) percolates deeply to the regional ground water system and is lost to stream .

Of the fraction that reaches the channel, its time of arrival is controlled by whether it flows primarily through the subsurface or over the surface, how quickly it is collected into

open channels on the hillside, and whether it is detained in reservoirs Or hampered by Impervious layers and Rushed away to lower areas.

Table No.3 Changes in Built up and recharge in wards of Bhopal.

S. N	WARD	Drop in Recharge % Average	Increase in Built up %
1	25(Tulsi nagar)	Decrease 75% to 25%	44.7 to 70.43%
2	26 (Panchsheel)	Decrease 95% to 11%	2.64% to 88.96%
3	27 (MANIT)	Decrease 99% to 69%	0.31 % to 11.71%
4	28(Chuna Bhatti)	Decrease 96.55 % to 58.85%	2.22% to 41.14%
5	45(Ravishankar Nagar)	Decrease 76.59 %to	76.6 % to 85.86%
6	48(Arera Colony)	Decrease 65.84 %to 6.73%	0.16 to 94.9%
7	52 (Shapura)	Decrease 95.55% to 51.71%	1.11 to 48.27%
8.	34 Jawahar nehru	Decrease 32.17% to 7.18%	58.52 % to 92.79%
1	Akbarpur	Decrease 94.63 to 36.79%	2.81 % to 63.23%
2	Nayapura	Decrease 94.28 to 78.52%	3.88 to 21.46%
3.	Bairagarh Chichli	Decrease 98.95 % to 96.46%	0.86 to 3.55%
4.	Neel bad	Decrease 95.65 % to 90.84%	1.01 % to 9.15%

- DATA USED :
- SOI Toposheets map on 1:50000 scale, Sheet No. 55E/8,
- SOI Toposheets map on 1:10,000.
- Remotely sensed data- 3 Feb 1991(Sheet No.1158), 06 January 1994(Sheet no.2209), 24 January 1996 (Sheet no. 2974), 24 March 2001 (Sheet No. 1287), 03 May 2009, from MPCST, Bhopal
- Geological Map 55-E.(From GSI, Bhopal)
- Georesource Map of Bhopal District.(From GSI Bhopal)
- Physiography map .(Topo Sheet 1975)
- Built up area ward wise and village wise.(Imageries)
- Water Table Fluctuations, Premonsoon & post Monsoon water level Data from CGWB (Centre for Ground Water Board) M.P & SWDC(State water Data Centre, M.P)
- Water Quality Data(Optional).
- Rainfall data , SWDC
- District Census Handbook , Bhopal District.

REFERENCES:

i. *Water cycle in urban areas, http://www.aquatic.unesco.lodz.pl/index.php.*

ii. *http://esa.un.org/unup/p2k0data.asp*

iii. *http://eol.jsc.nasa.gov/newsletter/DynamicEarth/Chapter3/Fig8.htm*

iv. *Sunil Kant Gupta, An Approach For Water Resources Assessment For Bhopal City and Environs Using Remote Sensing and GIS Techniques - A Case Study of Thesil Huzoor, Bhopal,2006, India. http://www.gisdevelopment.net/proceedings/mapindia/2006/wat.htm(accessed- Jan 2009)*

v. *.Web site of Central Ground water board, Bhopal. http://cgwb.gov.in/ncr/profile.htm*

vi. *Journal of environmental hydrology, The Electronic Journal of the International Association for Environmental Hydrology On the World Wide Web at http://www.hydroweb.com, VOLUME 12 , 2004.*

vii. *Web Site of Seatles Natural Drainage System.*

viii. *P. Konrad, U.s. geological survey, fact sheet 076-03, Effects of urban development on ,floods .*

ix. *Catchment Area, http:// www.floodsite.net/ juniorfloodsite /html/en /student/ things to know/ index.html.*

x. *Risk Assessment of Urban Water Systems for the City of the Future , Researcher: K. Khatri ; Mentor: A. Pathirana, PhD ; Promotor: Prof. K. Vairavamoorthy, PhD , http://www.unesco-ihe.org/Research.*

xi. *Blair Nancarrow, Research Team: Murni Po, Zoe Leviston, Natasha Porter, Juliane Kaercher HEALTHY COUNTRY, National Research Flagship, The Community and Water Reuse: What drives decisions to accept or reject? Australian Research Centre for Water in Society, CSIRO Land and Water.*

xii. *Reference: Basic Concepts of Groundwater, Hydrology, Publication 8083 FWQP REFERENCE SHEET 11.1, UNIVERSITY OF CALIFORNIA Division of Agriculture and Natural Resources, http://anrcatalog.ucdavis.edu*

xiii. *Dr Alka Bharat, Divya Sharma, Sunil Gupta , Facilitating Rain Water Harvesting and Storm Water Management for Recharging Groundwater in Urban Areas- A Case of Bhopal Region , , NOVATECH 2007 -221.*

xiv. *Comparative study of changing drainage basin system with tectonic forms, case study: Lut block, Iran, American Journal of Applied Sciences, June, 2009 by Ebrahim Moghimi*